Table 6 shows that the load carrying capacity of a double bearer - pole connection is significantly influenced by the bearer species. Refer Figure 13.

TABLE 6 CAPACITY OF DOUBLE LOAD BEARING SEATS IN MINIMUM 225 MM DIAMETER POLE

Bearer Strength Group	Double Seat Capacity kN	Floor Area Supported m^2
S3 or SD6	45	18
S5	29	12
S6	23	9.2

NOTE: Bolt is not load bearing for other than transfer of lateral loads.

It is to be noted that when seasoned timber is exposed to the weather or high moisture conditions it should be regarded as unseasoned for determining both its size and connection. This is not often a problem as the exposed peripheral members are usually not as heavily loaded as those at the interior of the building.

The cutting of the pole for these seats reduces the bending strength of the pole at this point by both a reduction in permissible bending stress and section modulus. The strength capacity at the notch is less than 30% of the intact pole for bending in a direction perpendicular to the bearers. Also, where the seat is exposed in timbers of less than Durability Class 1, the durability of the joint must suffer. In these situations, bolted connections without cut-in bearing seats are recommended. Cutting of poles should be kept to a minimum but where cuts are necessary, the area should be flood coated with preservative such as copper naphthenate.

Hardwood poles impart strength and flair to this observation tower and restaurant complex

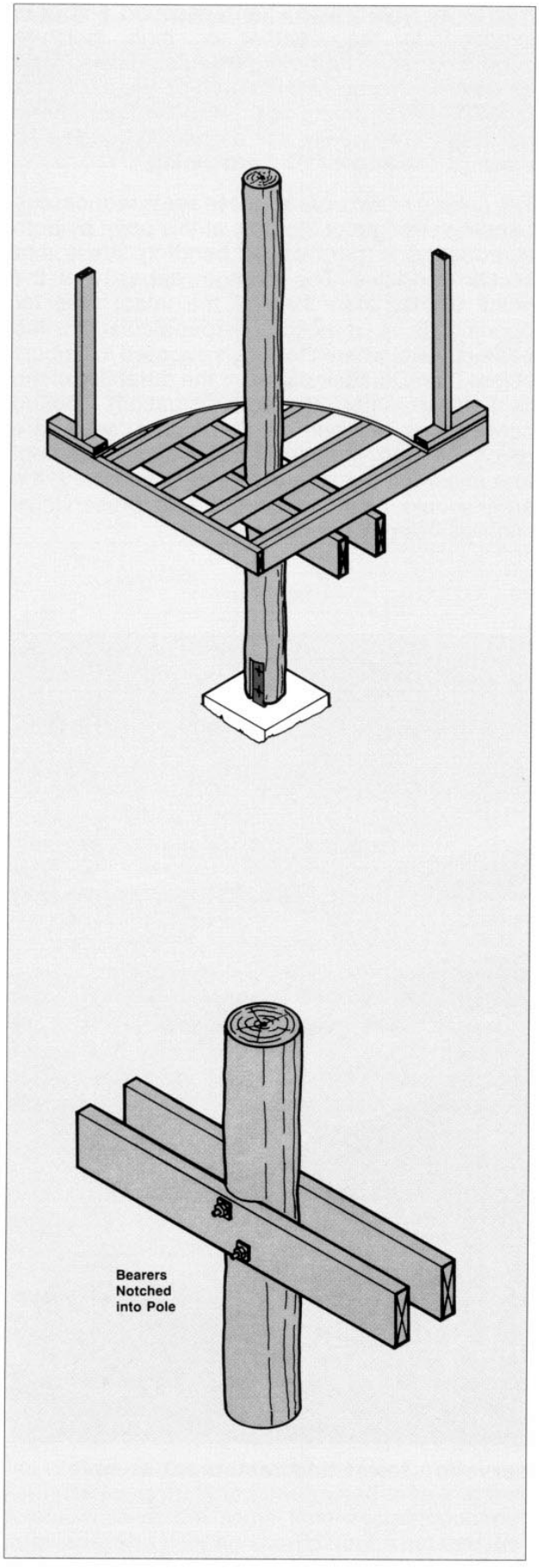

FIGURE 10 DOUBLE BEARERS

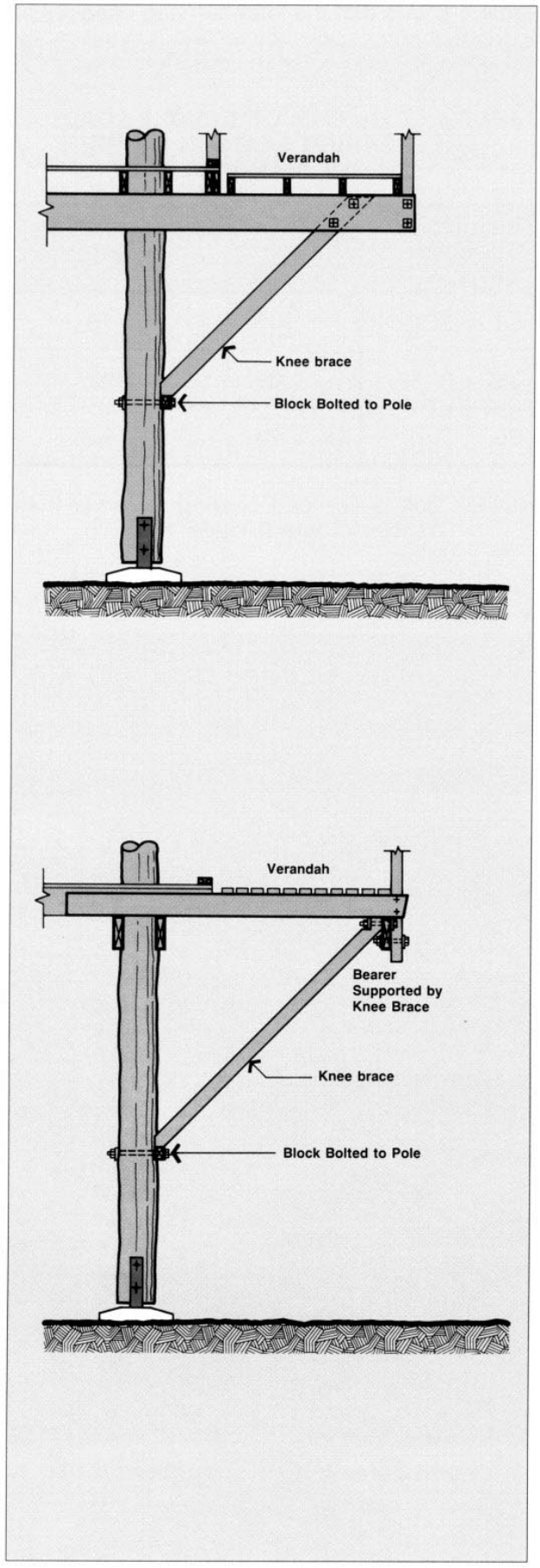

FIGURE 11 CANTILEVERS SUPPORTED BY KNEE BRACES

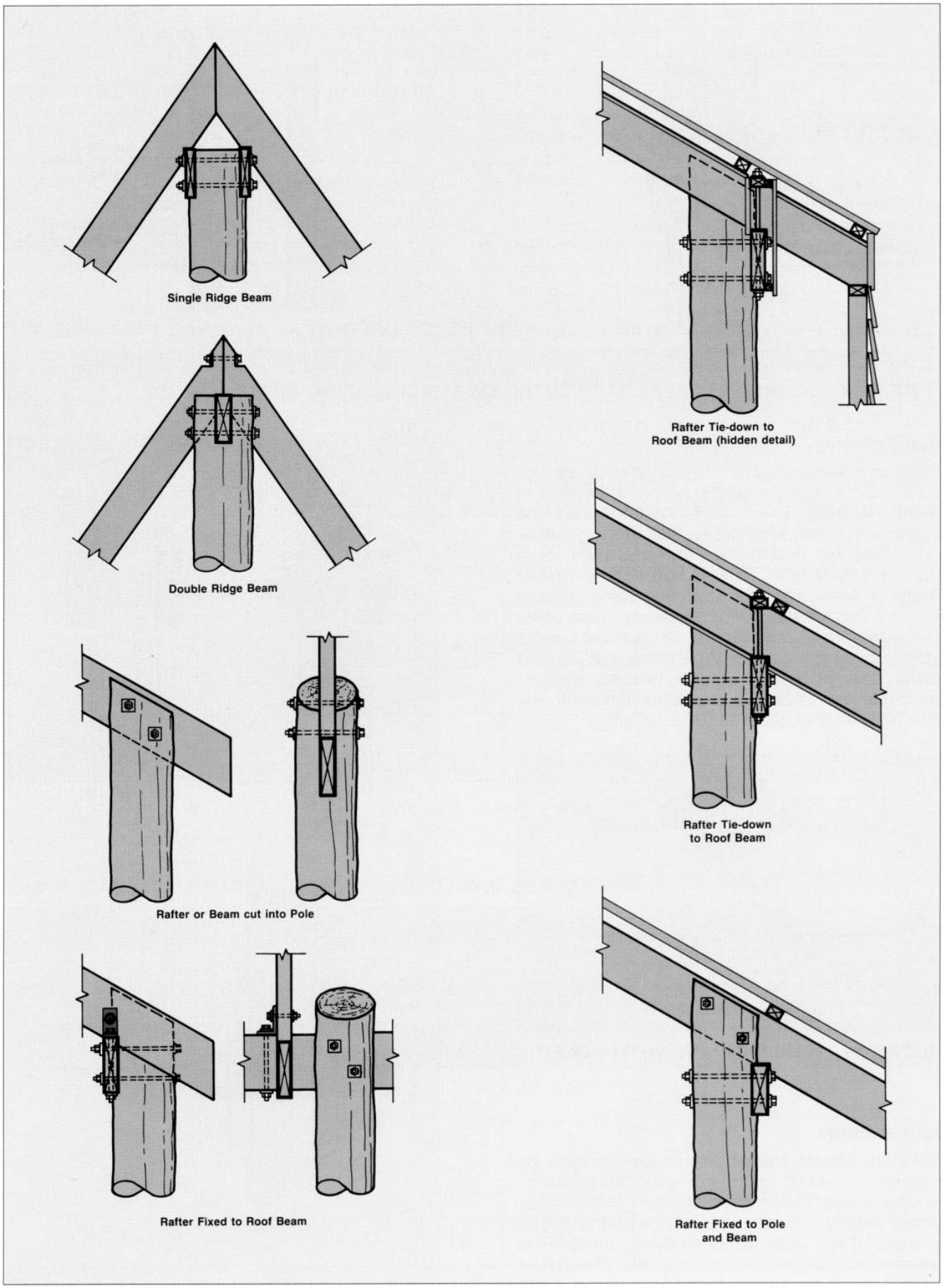

FIGURE 12 TYPICAL ROOF CONSTRUCTION DETAILS

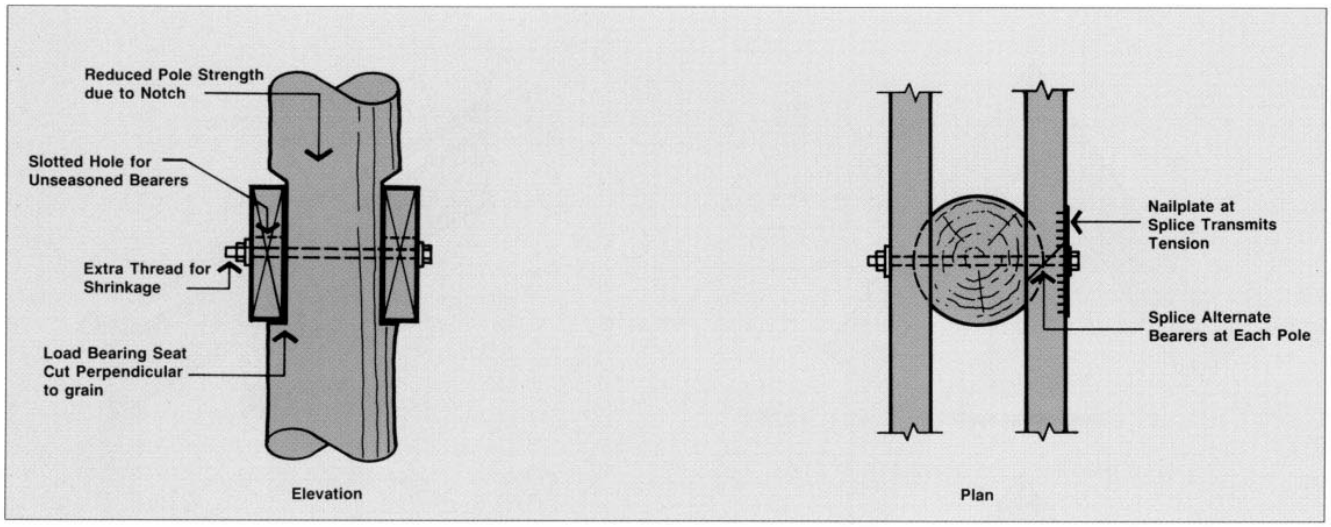
Reduced Pole Strength due to Notch
Slotted Hole for Unseasoned Bearers
Extra Thread for Shrinkage
Load Bearing Seat Cut Perpendicular to grain
Elevation
Nailplate at Splice Transmits Tension
Splice Alternate Bearers at Each Pole
Plan

FIGURE 13 DOUBLE BEARERS SUPPORTED ON LOAD BEARING SEATS

Wall Framing

Pole frame construction is a form of post and beam construction wherein wall framing is subject to lateral loading only. This loading may be significant in high wind areas. Wall framing timber sizes may be determined from AS 1684, SAA TIMBER FRAMING CODE or appropriate Timber Framing Manuals prepared by State Timber Industry Organisations. For situations where poles and walls are in-line, Figure 14 illustrates some typical jointing methods. Where the wall framing forms part of the structural bracing system, adequate tie must be provided between the bracing wall and the floor, roof or pole.

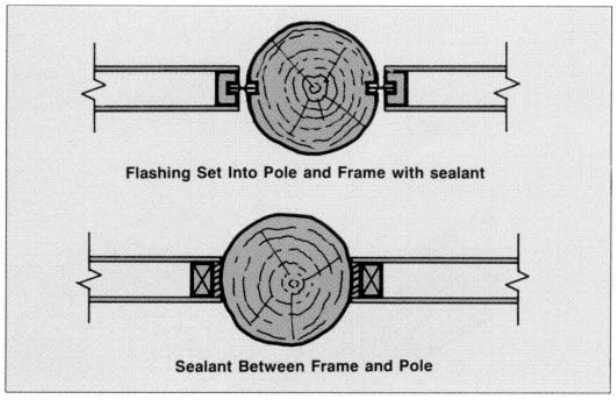

FIGURE 14 WALLS IN LINE WITH POLES

Bolted Joints

The load may be carried from bearer to pole by a variety of bolted joints. For exposed joints, or for unseasoned timber, the movement of the timber across the grain means that if more than one bolt is used they work against each other. The minimum spacings of bolts may also mean that there is insufficient room in which to locate bolts to develop the necessary strength. Refer Tables 7 to 10 for design loads of bolted joints. Figure 15 illustrates a range of pole-bearer connections.

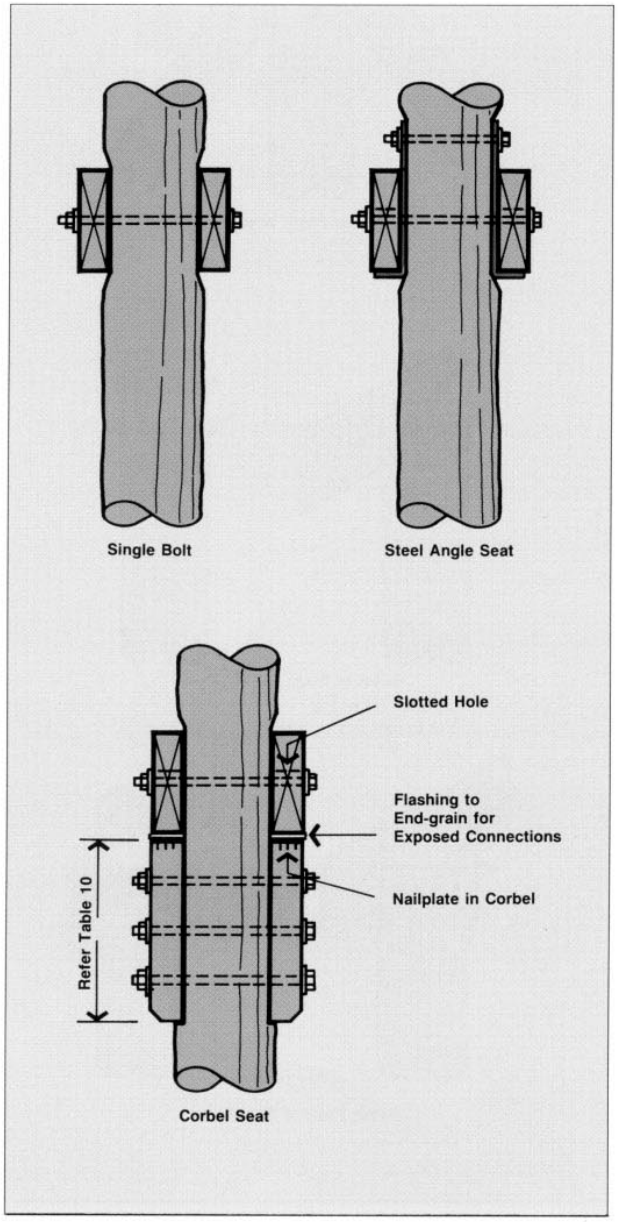

FIGURE 15 ALTERNATIVE POLE — BEARER CONNECTIONS

From the tables, it can be seen that bearer-pole connections relying on bolts alone are very limited, with the best achieving support of less than 10 m² of floor area. For joint strengths of individual species refer to Datafile P1, TIMBER SPECIES AND PROPERTIES.

Bull-dog connectors may be used to increase the capacity of softwood to softwood joints but are difficult to press into hardwood. Split-ring connectors and shear plates may also be used to increase the joint strengths and subsequently, the grid size but are difficult to install in round timber.

The angle bearing seat carries the bearer on the steel angle with the bolt hole in unseasoned bearers being elongated to accommodate shrinkage.

The steelwork should be hot dip galvanised and exposed connections should also be tar epoxy coated as well since they are such a critical element.

Both the corbel and the steel seat connections are limited by compression perpendicular to the grain in the bearers. Refer Table 11.

TABLE 7 BOLT CAPACITY — TWIN SEASONED BEARERS DOUBLE BOLTED (Refer Figure 15)

Bearer Width (mm)	Pole Joint Group	Bolt Sizes					
		2/M16		2/M20		2/M24	
		Strength kN	Area m²	Strength kN	Area m²	Strength kN	Area m²
45	JD3	13.6	6.8	17.2	8.6	20.4	10.2
	JD4	10	5	12.5	6.3	15.2	7.6
70	JD3	16	8	20	10	24	12
	JD4	12	6	14.8	7.4	17.6	8.8
Minimum Bearer Depth		210		260		320	

NOTE: "AREA" = maximum floor area supported for domestic loadings.

TABLE 8 BOLT CAPACITY — UNSEASONED TWIN BEARERS (Refer Figure 15)

Bearer Width (mm)	Pole Joint Group	Bolt Sizes					
		1/M20		1/M24		1/M30	
		Strength kN	Area m²	Strength kN	Area m²	Strength kN	Area m²
50	J3	6.6	3.3	8	4	10	5
	J4	4.2	2.1	5	2.5	6.2	3.1
75	J3	8.8	4.4	11.6	5.8	14.8	7.4
	J4	6.4	3.2	7.6	3.8	9.4	4.7
Minimum Bearer Depth		160		200		240	

NOTE: "AREA" = maximum floor area supported for domestic loadings.

TABLE 9 BOLT CAPACITY — STEEL ANGLE BEARING SEAT (Refer Figure 15)

Pole Joint Group	Bolt Sizes					
	2/M16		2/M20		2/M24	
	Strength kN	Area m²	Strength kN	Area m²	Strength kN	Area m²
J1	28	11.2	44	17.6	63	25
J2	23	9.2	36	14.4	52	21
J3	22	9	34	13.6	48	19
J4	17	7	26	10.4	38	15

NOTE: "AREA" = maximum floor area supported for domestic loadings.

TABLE 10 BOLT CAPACITY — CORBEL SEAT (Bolt strength only — check bearing strength as well) (Refer Figure 15)

Pole & Corbel Joint Group	Bolt Sizes					
	3/M16		3/M20		3/M24	
	Strength kN	Area m²	Strength kN	Area m²	Strength kN	Area m²
J1	42	17	65	26	94	38
J2	35	14	55	22	79	31
J3	32	13	50	20	73	29
J4	25	10	40	16	58	23
Corbel Height	400		500		550	

NOTES: 1. Corbels minimum size — 150 mm x 50 mm.
2. "AREA" = maximum floor area supported for domestic loadings.

TABLE 11 CORBEL SEAT BEARING CAPACITY (Area 2/150 x 50 mm)

Bearer Strength Group	Strength In Bearing kN	Floor Area m²
S1	100	40
S2	78	31
S3	62	25
S4	50	20
S5	39	16
S6	32	13

NOTE: Floor Area appropriate to domestic loadings only.

It is recommended that the end-grain of the corbel be effectively sealed by flashing and that a nailplate be used in the end-grain to control shrinkage in unseasoned timber.

Similar connection details may be used for roof beams often with single beams proving satisfactory.

Where high winds are involved (more than 33m/s) more attention needs to be paid to these connections and data from the various prescriptive design manuals should be followed or calculations made in accordance with AS 1170, Pt.2, SAA WIND LOADING CODE.

Bracing

Horizontal movement is caused by wind, earthquakes, people and vehicles and the effects can range from just perceptible to causing structural damage.

One approach is to design a structure to resist the appropriate wind (e.g. 33 m/s min.) with a limiting displacement of height from ground/300. Then, after construction, if vibration from activities are unacceptable, external bracing is retrofitted. Alternatively the bracing may be conservatively designed in the first place having due regard for the sensitivity of the proposed use and the non-structural walls that contribute to the overall damping of the structure. Obviously, buildings in high wind areas are designed to meet the stiffness requirements in response to the stipulated design wind velocity and therefore the structure is usually adequately braced against other forces.

The stiffness (Ref 9) of a variety of bracing elements are defined in manufacturers published test data. Besides having sufficient resistance to displacement, bracing systems need to have a natural frequency as far removed as possible from that causing the exciting; otherwise the structure resonates. That is, the intermittent applied force may act as the structure oscillates; the force adds to the force generated by the accelerating building (as it sways to and fro).

The natural frequency of cantilevered poles forming a Pole Platform is about 2 Hz (2 cycles/s) which is similar to that generated by walking i.e. disturbing vibrations could result. The cross-bracing maintained in a tight condition will bring a structures frequency to near 6Hz. This means that annoying motions are more economically overcome by using bracing than by providing more or larger poles. The disadvantage of course is the reduced freedom in location of walls especially at lower levels where racking forces are larger.

Common bracing systems used in pole construction are illustrated in Figure 16.

The procedure for designing the bracing system is as follows. The racking force to be resisted for each level is calculated from the dynamic wind pressure, the pressure coefficients and the wall and roof areas and orientations (AS 1170, Pt2 Ref 21). The nominal resistance of all of the elements at each level and direction are added until sufficient resistance has been mobilised.

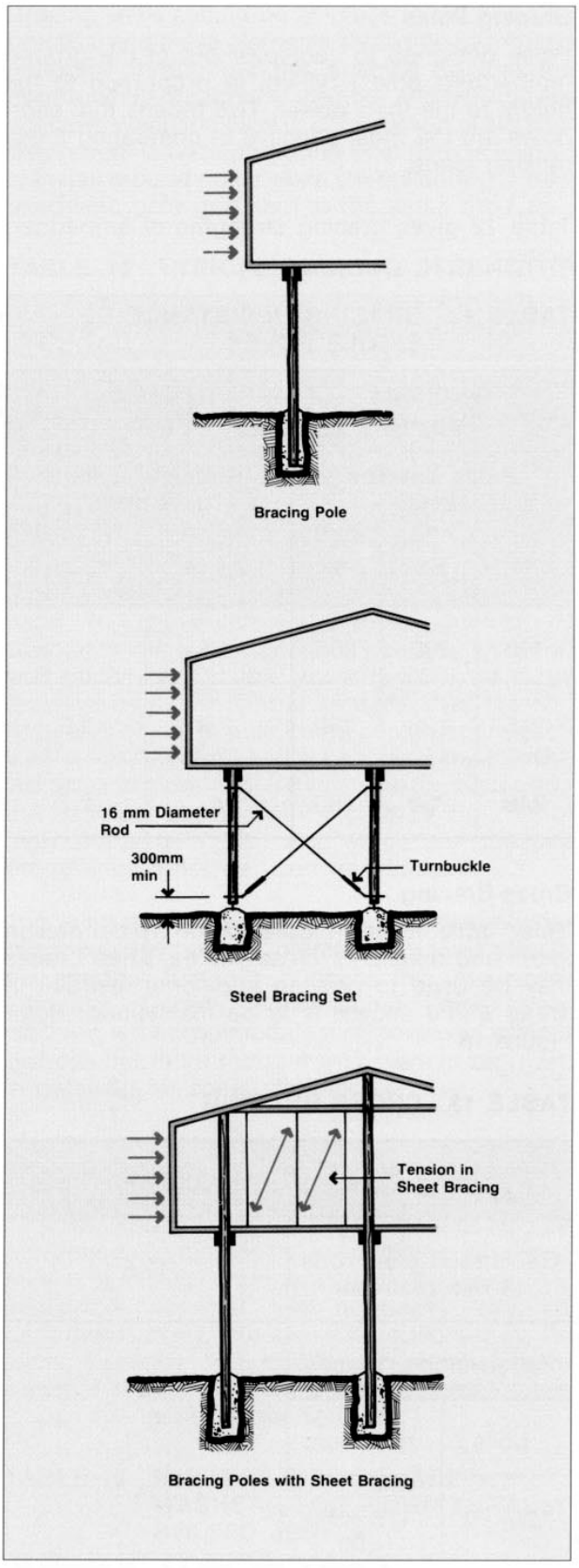

FIGURE 16 BRACING SYSTEMS

Wind force normal to surface = Dynamic pressure x Pressure Coefficient x Surface area.

Racking force = Sum of horizontal components of wind forces.

Bracing Poles

Poles designed to cantilever out of the ground (embedded poles) deflect in proportion to the height to the third power. This means that short poles are the most effective in combating these racking loads.

Table 12 gives bracing strengths of embedded poles.

TABLE 12 BRACING RESISTANCE OF SINGLE POLES

Small End Diameter			Resistance (kN)	
Poles Species Group			Height Out of Ground	
S3	S5	S6	2.4 m	3 m
190	200	205	1.5	1
215	225	230	2.5	1.6
240	250	260	4	2.2

Cross-Bracing

Refer Table 13 and Figure 17 for typical design loads and details for cross-braces. Knee braces may be used to provide additional restraint in areas where access is to be maintained. Refer Figure 18.

TABLE 13 CROSS-BRACING

Bracing Type		Resistance kN/Set
Galvanised steel rods 16 mm diameter		12.5
Paired timber braces		15
bolts	members	
2/M20	175 x 50 (J4)	
1/M20	125 x 75 (J3)	

NOTE: The rod bracing should be maintained in a tight condition. Turnbuckles may be used to accommodate any slackening due to timber shrinkage.

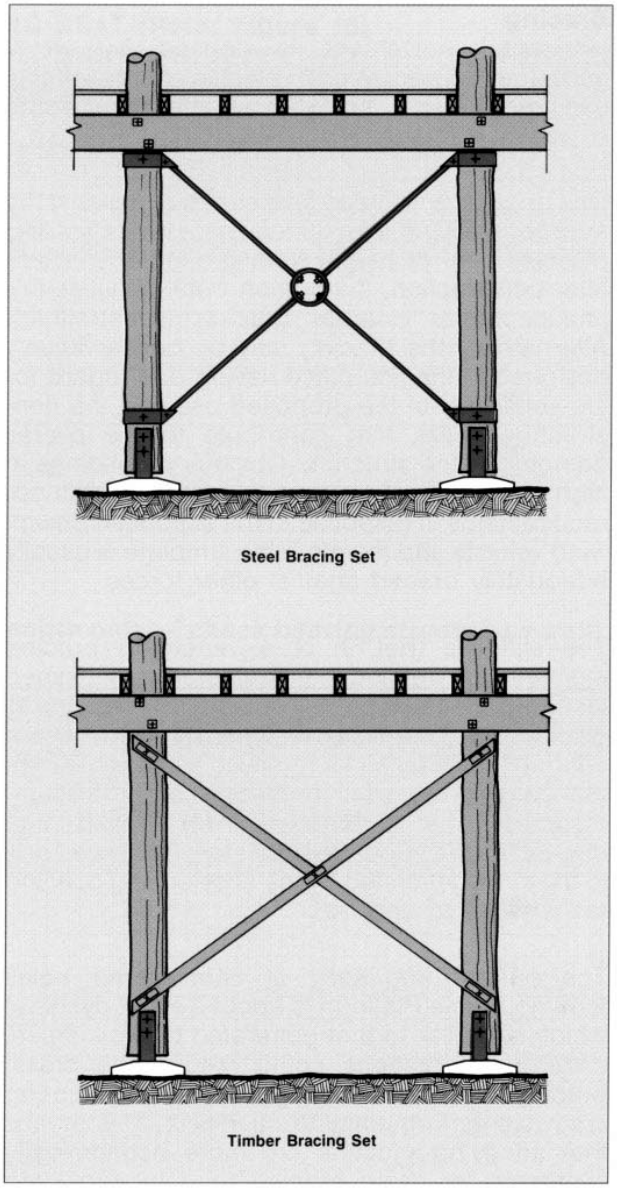

FIGURE 17 CROSS-BRACING

Bracing Walls

Bracing walls are normal stud walls with structural sheeting or diagonal timber or steel members concealed under the lining.

The sheet materials include plywood, plasterboard, hardboard or fibrous cement and are all structurally nailed to the frame. The type of nail and spacings are often different to those commonly specified for non-structural fixing. The frame is in turn rigidly attached to the floor and ceiling diaphragms, or poles. Refer manufacturers specifications.

Alternatively, these walls can be framed using let-in diagonal braces or even diagonal timber lining. The panels have known stiffness characteristics and from this the movement of the structure can be limited. Refer Table 14 for typical racking strengths. Construction details must comply with manufacturers specifications.